The Information-Based Approach to Environmental Policy: An Analysis of Green Electricity Programs in Michigan

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1. Introduction

Consumption of environmentally-friendly, or "green," electricity is a form of private provision of a public good. Green electricity is electricity produced from technologies that emit fewer pollution residuals than power plants using fossil fuels. Examples include solar, wind, biomass, and geothermal fuel sources. Green-electricity consumption is a voluntary contribution to cleaner air, that is, a form of private provision of an environmental public good. Green electricity programs are forming throughout the country. Over 80 electric utilities have established or designated green electricity programs (US Department of Energy, 2001). Michigan has four green electricity programs in operation: Traverse City Power & Light (begun in 1996), Detroit Edison (1997), Consumers Energy (2001) and Lansing Board of Water & Light (2001).

This research project analyzes green electricity consumption as a form of private provision of a public good. We develop two models of public-good provision that depict a consumer's decision to participate in a green electricity program. The models represent the two common types of green electricity programs. The two models are applied empirically using two data sets, one from Detroit Edison's green electricity program in southeastern Michigan and one from Traverse City Light & Power's (TCL&P) green electricity program in Traverse City, Michigan. We compare study results across the two programs. The research is the first descriptive analysis of subscription mechanisms found in existing green electricity programs.

Section 2 of this report continues with background on green electricity programs and a literature review. Section 3 outlines the theoretical framework applied in the research. Section 4 describes the data collected on the two green electricity programs. Section 5 reports the empirical results. Section 6 summarizes the research and draws conclusions from the project.

2. Background

2.1. Green Electricity Programs

Throughout the United States, green electricity is being offered to households as a supplement to electricity derived from fossil fuels and nuclear power. Production of green electricity displaces the pollution emissions and resource consumption associated with electricity generation from conventional fuels. As a pollution control strategy, green electricity relies on a willingness by consumers to incur a private cost for a public benefit. Program participants volunteer to pay a financial premium to meet all or part of their households' electricity demand with green electricity. Electric utilities use these programs to help finance their investment in green electricity production capacity. The number of utility-sponsored green electricity programs in the United States has grown in response to marketing studies that indicate a resounding preference and a willingness to pay more for renewable energy (Holt, 1997). Over 80 electric utilities have established or designated green electricity programs.

Two general types of green electricity programs exist: *green contribution programs* and *green tariff programs*. In a green contribution program, the amount of the financial premium paid by a household is independent of the household's electricity consumption. The green contribution occurs in the form of monthly or annual lump-sum payments. In contrast, in a green tariff program, the household's financial premium depends on its electricity consumption. The green tariff is a price premium charged on a cents per kilowatt-hour (kwh) basis. Consequently, the expense of participating in a green tariff program is relatively high for a household that consumes a relatively large amount of electricity.

The two program types create implications for economic modeling and analysis. First, what type of economic good does the program provide? A green contribution program provides a pure public good in the form of aggregate pollution emission reductions. A green tariff program provides an impure public good, electricity service and aggregate pollution emission reductions. Our research develops two models to address the two program types, a pure public good model and an impure public good model. Second, what are the behavioral implications of the two program types? A household deciding about a green contribution program chooses the amount of contribution. The contribution could be zero, i.e., a decision not to join the program. Or, if deciding to join the program, the household must decide on the level of lump-sum payments to contribute. In contrast, a household deciding about a green tariff program makes a simpler decision: whether to join the program (not how much to contribute). A decision to join the program, then, commits the household to a payment dependent on the price premium multiplied by the quantity consumed. Our research develops econometric models that reflect the different behavioral implications of the two program types.

These two types of programs are represented in the programs studied here, the Detroit Edison and TCL&P programs. Since these two green electricity programs are representative of national trends, they are important to analyze in general and for the State of Michigan in particular. Both programs were marketed as a way for individuals to improve environmental quality, particularly through reduction in carbon dioxide, sulfur dioxide, and nitrogen oxide emissions associated with generation of electricity from fossil fuels.

Detroit Edison's *SolarCurrents* program is a green contribution program. Customers choose the level of contribution by enrolling for a certain number of "blocks" of the program. A subscriber to the program pays an additional fee of $6.59 per block per month. 281 households joined the *SolarCurrents* program. Subscriptions to the program range from 1-7 blocks. Customers sign a two-year contract to enroll in the program.

TCL&P's *Green Rate* program is a green tariff program. After a direct mailing of all customers to solicit voluntary participation in the program, 263 households signed up to purchase 100 percent of their electricity at a price premium. Participants sign a three-year contract agreeing to pay 1.58 cents per kwh on top of an average rate of 6.8 cents per kwh, a premium of 23 percent. For the average household, this is an additional $7.58 per month.

2.2. Literature Review

The success of green electricity programs, along with recent rulings at the federal and state level opening the door to retail competition among electricity producers, indicate that the number of green electricity programs is likely to continue growing (Wiser and Pickle, 1997). To date, economic studies of green electricity have explored stated preferences for green electricity and normative properties of a provision point mechanism for subscription. Either *et al.* (1997) analyze contingent valuation responses to compare survey responses across phone and mail survey modes. Teisl, Roe, and Levy (1999) evaluate the effect of different types of ecolabeling information on contingent ranking and contingent choice of various types of green electricity. Rose *et al.* (1997) compare results from a field experiment to an induced value experiment in the laboratory to test whether a provision point mechanism eliminates free riding. In contrast to these studies, our research investigates positive, descriptive properties of subscription mechanisms found in existing green electricity programs.

Environmental policy in the United States is implemented with a pluralistic mix of command-and-control, market-based incentives, and information-based strategies. The limited experience with the information-based approach makes it premature to draw conclusions about the "efficient niche" for information disclosure relative to the other instruments (Tietenberg, 1998). Recent research on the information-based approach has primarily focused on producer or investor behavior (e.g., Arora and Cason, 1996; Khanna, Quimio, and Bojilova, 1998; Konar and Cohen, 1997). This research contributes to the ongoing assessment of information-based strategies by focusing on consumer behavior.

The research applies models from public-goods theory on the private provision of public goods. Theoretical models to explain the private provision of public goods have evolved over the last 30 years. Bergstrom, Blume, and Varian (1986) and Andreoni (1988) develop the contemporary model of a privately-provided pure-public good. The model generates predictions about the influence of income and tastes on free-riding versus contributing behavior in a Nash equilibrium. The incentive to contribute increases in income and a taste for the public good. Moreover, increases in group size lead to lower fractions of individuals making contributions.

Empirical tests of the pure public good model include applications using data from field and laboratory experiments. Studies using field data include analysis of CFC emissions and the Montreal Protocol (Murdoch and Sandler, 1997) and voluntary contributions to a rural health-care facility (Smith, Kehoe, and Cremer, 1995). Laboratory experiments have focused on trying to explain a persistent anomaly: the frequency of contributions in light of the dominant strategy to free ride (Ledyard, 1995). Andreoni (1995) and Palfrey and Prisbrey (1997) find that different forms of altruism explain the discrepancy between actual and predicted public-good contributions.

Altruism in the pure public goods model is a special case of the impure public goods model (Andreoni, 1990). Cornes and Sandler (1984, 1994) analyze the impure public goods model to demonstrate the general case, in which a single commodity jointly provides a private good and a public good. An example is TCL&P's green electricity program, in which consumers pay a fixed price premium per kwh. In this program, a consumer receives electrical service as the private good and pollution emission reduction as the public good. Other programs, such as

Detroit Edison's program, provide only a public good since contributions are a lump-sum fee that is divorced from electricity consumption. Thus, analyzing different green electricity programs requires different models of public-goods provision.

Empirical applications of the impure public good model include studies of contributions to public radio (Kingma, 1989), agricultural research expenditures in the United States (Khanna, Huffman, and Sandler, 1994), and national defense expenditures (Murdoch and Sandler, 1984). None of these studies, however, analyze the influence of price on individual contributions to the private provision of an impure public good. This research is the first analysis to do so.

3. Theoretical Framework

This section provides economic models of participation in both types of green electricity programs in Michigan. First we consider Detroit Edison's *SolarCurrents* program, which exemplifies private provision of a pure public good. Second we consider Traverse City Light and Power's *Green Rate* program, which exemplifies private provision of an impure public good with an "all-or-nothing" decision.

3.1. Detroit Edison's SolarCurrents Program: Private Provision of a Pure Public Good

The model of private provision of a pure public good is developed by Bergstrom, Blume, and Varian (1986) and Andreoni (1988). The individual chooses a personal contribution to the public good (g_i) while taking all others' contributions (G_{-i}) as given. Total provision (G) simply sums g_i and G_{-i}. The price of the public good is p. Define x_i as the composite private good and w_i as income. The utility function ($U(\bullet)$) is well defined, with individual tastes represented by the vector θ.

The individual's problem can be written as

$$\max_{x_i, G} \{U(x_i, G; \theta) : x_i + pG = w_i + pG_{-i}, G \geq G_{-i}\}.$$

Solving this problem yields

$$G = \max\{G_{-i}, f(w_i + pG_{-i}; \theta)\}.$$

Then in equilibrium we have

$$g_i^* = \begin{cases} 0 & \text{if } w_i \leq w^*(\theta) \\ w_i/p - w^*(\theta) & \text{if } w_i > w^*(\theta) \end{cases},$$

where $w^*(\theta) \equiv f^{-1}(G^*; \theta)/p - G^*$. Individuals who do not contribute ($g_i^* = 0$) free ride on the contributions of others, G_{-i}.

3.2. TCL&P's Green Rate Program: Private Provision of an Impure Public Good

The model of private provision of an impure public good is developed by Cornes and Sandler (1984, 1994). Assume initially that consumers have preferences over characteristics of goods rather than goods themselves. In this case, green electricity (q_i) is the economic good; green electricity provides two characteristics: electricity (y_i) and pollution reduction (z_i). The price of green electricity is p_q. A technology parameter (α) translates green-electricity consumption into pollution reduction. As a public-good characteristic, pollution reduction is also provided by other consumers (Z_{-i}). Total provision (Z) simply sums z_i and Z_{-i}. Other variables are defined as before.

Our goal is to model the discrete choice of whether to participate in the program. We start by deriving the indirect utility function of an individual who is enrolled in the program. The individual's problem can be written as

$$\max_{x_i, q_i} \left\{ U(x_i, y_i, z_i + Z_{-i}; \theta) : y_i = q_i,\ z_i = \alpha q_i,\ x_i + p_q q_i = w_i,\ Z \geq Z_{-i} \right\}.$$

The maximized value of the objective function can then be written as an indirect utility function

$$V(p_q, w_i, \alpha, Z_{-i}; \theta).$$

Yet without green electricity, the individual only has the opportunity to consume conventional electricity, c_i where $c_i = y_i$. The price of conventional electricity is $p_c < p_q$, and conventional electricity is distinguished from green electricity because $\alpha = 0$. The indirect utility function for this choice setting can be written as

$$V(p_c, w_i, 0, Z_{-i}; \theta).$$

It follows that in equilibrium, an individual of type θ chooses to participate in the program if

$$V(p_q, w_i, \alpha, Z_{-i}; \theta) > V(p_c, w_i, 0, Z_{-i}; \theta).$$

As above, individuals who do not participate in the program free ride on the pollution reduction of others, Z_{-i}.

4. Data and Variables

This section describes the data collected from the Detroit Edison and TCL&P programs.

4.1. Detroit Edison's SolarCurrents Program

Mail surveys were sent to 281 participants and 619 nonparticipants in Detroit Edison's program. The sampling regime was choice-based sampling. The 281 participants comprise the complete population of participants, while the sample of 619 nonparticipants was randomly selected from

80,000 Detroit Edison customers. The survey was administered in the winter of 1998 using the Dillman (1978) Total Design Method. Seventy-two surveys were not deliverable due to address changes. Response rates were 95% for participants, 67% for nonparticipants, and 76% overall.

The survey asked all respondents to complete two scales: a nine-item altruism scale and a ten-item modified New Ecological Paradigm (NEP) scale. We use these scales to measure two consumer tastes, an altruistic taste and an environmental taste. A five-point Likert response scale (ranging from "strongly agree" to "strongly disagree") was used for each item in both scales. We apply the Schwartz norm-activation model in the form of a general altruism scale to measure altruistic attitudes. The altruism scale was constructed as a new scale for this research. The scale contains a total of nine items; specific items are listed in the Appendix.

The modified NEP scale consists of 10 items from the original 15-item NEP scale (Dunlap *et al*., 2000). Two statements are used from each of the five facets of environmental concern in the scale. Specific items for the NEP scale are listed in the Appendix. The five items excluded from the original scale were selected based on low item-total correlations reported in previous studies (Dunlap *et al*., 2000; Kotchen and Reiling, 2000). They were excluded to reduce the length of the survey instrument.

The Detroit Edison study preceded the Traverse City study. To shorten questions for the two scales in the Traverse City study, we removed items that were less influential in the Detroit Edison study. By removing only selected items, the scales differed between studies, yet qualitative comparisons remain valid.

The survey also collected data on age and gender of the respondent, and on the number of people in the household.

4.2. TCL&P's Green Rate Program

We completed a mail survey of residential customers of TCL&P during summer 2001. A sample of 1,000 residential customers was developed. Of the 1,000 surveys, 28 surveys were not deliverable; 677 surveys were returned; and 295 surveys were not returned. This is a response rate of 69.6% (677/972). In the TCL&P sample, the number of participants is 106, the number on the waitlist is 27, and the number of nonparticipants is 544. In the analysis, we consider those on the waitlist as participants.

As in the Detroit Edison survey, the TCL&P survey asked all respondents to complete two scales as a basis to measure an altruistic taste and an environmental taste. To reduce respondent burden, the altruism scale was shortened to six items and the NEP scale was shortened to five items. The Appendix reports the items used in the TCL&P survey. The survey also collected data on age and gender of the respondent, and on the number of people in the household.

We merged the survey data with data from TCL&P on electricity consumption since 1994. The electricity data include observations for 677 households over 108 months (1994-2002). A variable for the "effective price" of participating in the TCL&P program is formed from the electricity consumption data.

4.3. Variables

The two data bases generate a common set of variables for the empirical analysis. The variables are defined as:

NEP = summated scale from New Ecological Paradigm (NEP) items,
ALT = summated scale from altruism items,
AGE = age of respondent,
GENDER = gender of respondent (1=male; 0= female),
HOUSEHOL = number of people in household,
INC000 = annual household income in thousands of dollars, and
ELECDAY = household's average electricity consumption per day.

ELECDAY is a variable in the TCL&P data base; it does not exist in, and it is not relevant to, the Detroit Edison data base. Developing a common set of variables creates a basis to compare the two programs.

5. Empirical Analysis

Note that although we have endogenous, or choice-based, sampling, we do not weight in our statistical analysis. Weighting would generally be necessary to avoid biased statistical analysis when the objective is to extrapolate results to the entire population. In this study, however, we are only interested in analyzing behavior of individuals in the sample; therefore, weighting is unnecessary.

Table 1 lists summary statistics for the variables included in the analysis. These are stratified by participants, nonparticipants, and combined. In the Detroit Edison sample, the number of participants is 264, and the number of nonparticipants is 359. In the TCL&P sample, the number of participants is 133 (including households on the waitlist) and the number of nonparticipants is 544.

Table 1 also reports a statistical test of the comparison of means, by variable, between participants and nonparticipants. It shows which variables are statistically different between the two groups. Figures 1-4 compare the means, by variable, between participants and nonparticipants.

Table 2 lists the frequency distribution of the number of blocks purchased by participants in the Detroit Edison sample.

5.1. The Detroit Edison Program

A tobit model is the empirical implication of the contribution function in the theoretical model of participation in the Detroit Edison program. This follows because all households of type θ with incomes below $w^*(\theta)$ are censored to $g_i^* = 0$. Then if income lies above this threshold, contributions are a linear function of income.

We estimate this model, and the results are shown as Model I in Table 3. The dependent variable is the number of blocks purchased, which is a function of income and other covariates that capture the heterogeneity implied by θ.

The key theoretical prediction from the pure public good model relates to the coefficient on income (*INC000*). Data are based on annual income, so we also interpret dollar figures on an annual basis. The monthly price per share is $6.59, so the annual price per share is $79.08. Thus, 1/p is 1/79.08, or 0.013. This is the theoretical prediction for the coefficient.

How does this compare to the slope coefficient we estimate? Since we measure income in 1,000s of dollars we need to multiply the prediction by 1,000, which yields a prediction of 13. Note that this prediction is far greater than our actual estimate of 0.003.

The variable *HOUSEHOL* reflects a household's disposable income: disposable income decreases as the number of people in the household increases (holding *INC000* constant). The estimated coefficient is consistent with this interpretation; the number of blocks purchased decreases in *HOUSEHOL*.

Other variables are related to consumer tastes. Our priors are that *NEP* and *ALT* exert a positive effect on blocks purchased and that *GENDER* exerts a negative effect (the literature suggests that women are more likely to contribute to public goods than men). We have no priors on *AGE*. The results prove interesting primarily because the insignificance of most taste variables. *ALT* has the anticipated effect, yet the coefficient on *NEP* is insignificant. *GENDER* and *AGE* have no effect.

The nature of the data analyzed here also suggests estimation of a count data model. The number of blocks households could purchase are in discrete units, and there is a preponderance of zeros and small values. The poisson regression model is typically used to analyze such data (Greene, 2000). We estimate this model and report the results as Model II in Table 3. Note that there is very little difference between the two models in terms of significance and the marginal effects.

Taking literally the theoretical model for participation in the Detroit Edison program, there is no difference between factors that explain participation at the extensive and intensive margins. Other studies, however, suggest that there may be reasons why different factors may explain participation at the extensive and intensive margins (Smith, Kehoe, and Cramer, 1995; Rose-Ackerman, 1996).

In order to investigate this possibility in the Detroit Edison data, we estimate both margins separately. We separate the margins by first estimating a probit model of the participation decision (where 1=yes, 0=no). Then, using only the participants, we estimate both a truncated linear regression model and a truncated poisson model. These models parallel those already discussed, but account for exclusion of the nonparticipants.[1]

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[1] Smith, Kehoe, and Cramer (1995) estimate both margins jointly with a Heckman selection model. We estimate both margins separately for two reasons. First, there is no need to correct for selectivity bias since nonparticipants are really nonparticipants; that is, there is no sample selection over participants. Second, there are no *a priori*,

The results of all three models are reported in Table 3 as model III, IV, and V. Note that we find evidence for differences in the covariates that explain participation and the extent of participation. Variables that affect the extensive margin are *NEP*, *ALT*, *GENDER*, *HOUSEHOL*, and *INC000*. The only variable that affects the intensive margin is *INC000*.

These results suggest that one set of factors—tastes, gender, and income—motivate the decision to participate in the program, but only income affects the level of participation. This behavior would be consistent with a "buy-in effect." Rose-Ackerman (1996) conjectures that a "buying-in" mentality influences altruistic behavior: "donors …may feel that they deserve to feel good about the charitable program only if they have made some marginal contribution to it. For each person, there is a discontinuity in the marginal benefits of gift giving at his or her threshold" (p. 713). From this perspective, tastes and gender motivate the buy-in effect of purchasing one block of the program; only income influences the choice of how many blocks to purchase. These results suggest a need for theoretical analysis of the buy-in effect.

5.2. The TCL&P Program

Now we shift to TCL&P's *Green Rate* program. Here households only have the dichotomous choice of whether or not to participate in the program. Based on the theoretical model, factors that should influence participation are the price premium $p_q - p_c$, income w_i, spillins Z_{-i}, the technology of green electricity α, and any other variables that account for heterogeneity of preferences θ. Since the level of spillins is approximately equal for all households, there is no variation in this variable to include in the empirical specification. This is also the case for the green electricity technology. It is also the case that all households face the same price premium for participation in the *Green Rate* program. Therefore, we have no variation in the price premium variable itself.

This, however, does not imply that all household face the same "effective price" for participation in the program. Given that the capital stock of any household is generally fixed (at least in the short run), it is reasonable to assume that electricity use is exogenous to participation in the *Green Rate* program. This assumption is also supported by the fact that electricity consumption is very inelastic. Thus, households with low levels of electricity use face a lower effective price for participation than do households with greater electricity use. We capture the idea of this effective price with *ELECDAY*.

Table 4 reports estimated probit models for the participation decision. For comparison purposes, we estimate the model with and without *ELECDAY*. Note that only taste variables matter in Probit I. When we add *ELECDAY*, it is significant with the expected sign, and *INC000* becomes significant with the expected sign. Thus, effective price matters, and without it income is not a significant predictor of participation. A plausible reason for this latter result is that households with higher income tend to consume more electricity (note the correlation between the two variables is reasonably high, 0.34). Therefore, the income effect is offset by an effective price

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identifying restrictions to impose on either equation since theory predicts that the same covariates should explain both margins.

effect, and both effects are offsetting with only *INC000* in the model. Both effects, however, become significant when they are separated out in Probit II.

How do we interpret the marginal effect on *ELECDAY*? For the average household, an increase in electricity demand of one kwh per day—which is an increase of roughly 5.6 percent, and an additional premium of 1.58 cents—decreases the probability of participating in the green electricity program by almost half of a percent (0.4 percent). Note that this is on top of a premium already being paid of 18x1.58= 28.44 cents. Note further that on an annual basis this is an increase $5.77 on top of an existing premium of $103.81.

5.3. Comparing the Programs

Who participates in green electricity programs? The main comparison between the TCL&P and Detroit Edison programs occurs in the probit models. Compare Model III in Table 3 and Probit II in Table 4. By controlling for the effective price (or level of contribution) of the TCL&P program, the inclusion of *ELECDAY* in Probit II makes the two sets of results comparable. The common factors that affect participation are *NEP*, *ALT*, and *INC000*. *AGE* does not affect participation in either program. *GENDER* and *HOUSEHOL* affect participation in the Detroit Edison program, but not in the TCL&P program.

The marginal effects, or slopes, of the common factors are also interesting. The marginal effects of *NEP* and *ALT* are similar in magnitude across programs; these cannot be compared rigorously because the variables are measured somewhat differently across the two studies. The marginal effects of *INC000*, however, can be compared rigorously. An impressive result is that *INC000*'s marginal effect is identical across studies: 0.001. That is, household income exerts the same effect on the participation decision for both programs.

6. Summary and Conclusions

Voluntary participation in green electricity programs is a form of private provision of an environmental public good. Through participation, individual households contribute to the program's reduction in air pollution emissions (and corresponding improvement in air quality). Electric utilities throughout the country are developing green electricity programs. Two types of programs are common: green contribution programs and green tariff programs.

We study two green electricity programs in Michigan. Detroit Edison's *SolarCurrents* program is a green contribution program. Subscribers to the program pay $6.59 per month per block of the program. Their monthly payment to the program is independent of electricity use. TCL&P's *Green Rate* program is a green tariff program. Subscribers pay *an additional* $1.58 cents per kwh. Their monthly payment thus varies directly with electricity use.

The research applies two economic models of individual behavior in public provision of private goods: a pure public good model and an impure public good model. Data were collected on characteristics of households served by Detroit Edison and TCL&P, with both participating and nonparticipating households sampled. Several econometric models are applied to analyze the two samples.

We estimate a tobit model to understand subscriptions to the pure public good provided by the Detroit Edison program. Variables for household income and household size yield the anticipated effects: the number of blocks purchased increases in household income and decreases in household size. A taste variable for altruistic attitude affects purchases positively, while a taste variable for environmental attitude exerts no effect. Variables for age and gender also exert no effect. A count data model reaches the same conclusion on the sign and significance of the variables.

Separating the subscription decision into extensive and intensive margins yields interesting results when compared to the tobit model. Using a probit model, variables for environmental taste and gender affect the decision to subscribe (extensive margin) in addition to variables for income, household size, and altruistic taste. Using a truncated regression, only income affects the number of blocks purchased by subscribers (intensive margin). These results suggest that women, altruists, and environmentalists tend to "buy in" to the program at the lowest possible option of one block. The results suggest that returning to the theory to develop implications of a model of the "buy-in effect" would be productive.

With the TCL&P program, we estimate a probit model based on the theoretical model of an impure public good. Positive factors include altruistic taste, environmental taste, and household income. The sole negative factor is the variable for effective price, which measures electricity use as a direct surrogate for a household's expenditure on the green tariff. As expected, the probability of participation decreases as the effective price increases. This result is a novel contribution to understanding the price elasticity of household participation in a green tariff program.

In comparing the two programs, we find that household income and tastes affect participation in both programs. The positive signs on the income variables are expected based on theory. An interesting finding is that both tastes matter. These two tastes – environmental attitude and altruistic attitude – are sufficiently distinct that both are significant factors in the multivariate model.

While we study the two major types of programs, the green tariff program has a few permutations in program design. Under the TCL&P program, the green rate applies to all the electricity consumed by the household. For example, a household pays the price premium of $1.58 cents per kwh on all electricity used. Other programs give the household a choice over the quantity of electricity to which the green rate applies. In Colorado, a program allows the customer to choose the fraction of electricity under the green rate. The higher rate can apply to 25%, 50%, 75%, or 100% of the household's monthly use. In Michigan, Lansing Board of Water & Light allows the customer to choose the quantity of electricity under the green rate in multiples of 250 kwh per month. For example, a household in the program chooses whether the green rate covers 250, 500, 750, and so on, kwh per month.[2] (The average household uses

[2] This program could operate as a green contribution program under some circumstances. For example, a household would be making a lump-sum contribution if it chose to pay a green rate on a quantity of 250 kwh per month, yet always consumed a range well above 250.

slightly more than 500 kwh per month.) These other designs of green-tariff programs would be interesting to study.

A second interesting topic is the relationship between demand for green electricity and exogenous local air quality. Standard public-goods theory predicts that public provision crowds out private provision on a 1:1 basis, i.e., that public provision substitutes perfectly for private provision. Air-quality regulation is a form of public provision. In addition, regions such as rural areas might have relatively clean air simply because relatively low economic activity. The research question here is whether exogenous air quality affects participation in a green electricity program. Empirical research is needed to establish whether, and to what degree, private provision of green electricity substitutes for government regulation of air quality. This is an important public-policy issue.

An ongoing concern is the free-rider problem: individuals can benefit from cleaner air without subscribing to a local green electricity program. In the two programs studied here, many respondents to the survey marked that these particular programs are a “very good idea” or “good idea.” Very few of these respondents actually enrolled in the program, which suggests that a free-rider motive may affect participation. The ability to free ride will always limit the effectiveness of private supply of environmental public goods.

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Table1: Summary Statistics: Variable Means and Standard Deviations

	Detroit Edison			TCL&P		
	Participants	Nonparticipants	Combined	Participants	Nonparticipants	Combined
NEP	37.8***	33.9	35.6	20.3***	17.2	17.9
	(7.3)	(6.9)	(7.3)	(3.6)	(4.1)	(4.2)
ALT	35.1***	31.0	32.8	24.8***	22.5	23.0
	(4.6)	(5.2)	(5.3)	(3.3)	(3.7)	(3.7)
AGE	52.3	51.3	51.7	56.1	60.5	59.6
	(12.9)	(13.5)	(13.3)	(13.6)	(14.9)	(14.7)
GENDER	0.58	0.70	0.65	0.52	0.53	0.52
	(0.49)	(0.46)	(0.48)	(0.50)	(0.50)	(0.50)
HOUSEHOL	2.5	2.9	2.8	2.3	2.2	2.2
	(1.3)	(1.5)	(1.4)	(1.1)	(1.3)	(1.3)
INC000	79.7***	66.8	72.5	66.5***	56.9	58.9
	(46.7)	(42.5)	(44.8)	(35.5)	(34.6)	(35.0)
ELECDAY	-	-	-	16.6	18.0	17.7
				(8.6)	(10.1)	(9.8)

Notes: Standard deviations are given in parentheses. Significant differences between participants and nonparticipants are indicated by *, **, and *** at the 0.1, 0.05, and 0.01 levels, respectively. *NEP* = summated scale from New Ecological Paradigm (NEP) items, *ALT* = summated scale from altruism items, *AGE* = age of respondent, *GENDER* = gender of respondent (1=male; 0= female), *HOUSEHOL* = number of people in household, *INC000* = annual household income in thousands of dollars, and *ELECDAY* = household's average electricity consumption per day.

Table 2: Frequency of blocks purchased by participants in the Detroit Edison sample

Number of blocks	1	2	3	4	5	6	7
Number of households	206	28	13	7	3	4	1

Notes: The number of blocks is missing for two participant observations.

Table 3: Models of contributions to Detroit Edison's *SolarCurrents* program

	Model									
	I. Tobit		II. Poisson		III. Probit		IV. Truncated Regression		V. Truncated Poisson	
	Coefficient	Slope	Coefficient	Slope	Coefficient	Slope	Coefficient	Slope	Coefficient	Slope
Constant	-5.236***		-3.308***		-3.916***		1.285		0.487	
	(0.932)		(0.556)		(0.599)		(1.703)		(0.944)	
NEP	0.019	0.008	0.012	0.007	0.018*	0.007*	0.000	0.000	-0.001	-0.000
	(0.015)	(0.007)	(0.009)	(0.007)	(0.010)	(0.004)	(0.027)	(0.012)	(0.015)	(0.010)
ALT	0.123***	0.054***	0.067***	0.044***	0.092***	0.036***	-0.038	-0.016	-0.031	-0.018
	(0.022)	(0.010)	(0.013)	(0.010)	(0.014)	(0.006)	(0.044)	(0.019)	(0.025)	(0.019)
AGE	0.007	0.003	0.001	0.001	0.007	0.003	-0.010	-0.004	-0.010	-0.006
	(0.008)	(0.003)	(0.005)	(0.003)	(0.005)	(0.002)	(0.014)	(0.006)	(0.008)	(0.006)
GENDER	-0.199	-0.087	-0.031	-0.020	-0.232*	-0.091*	0.362	0.154	0.339	0.196
	(0.198)	(0.086)	(0.119)	(0.088)	(0.130)	(0.051)	(0.361)	(0.154)	(0.213)	(0.161)
HOUSEHOL	-0.183**	-0.080**	-0.103***	-0.068*	-0.145***	-0.057***	0.070	0.030	0.064	0.037
	(0.076)	(0.033)	(0.048)	(0.036)	(0.049)	(0.019)	(0.135)	(0.057)	(0.075)	(0.052)
INC000	0.007***	0.003***	0.005***	0.003***	0.003**	0.001	0.008**	0.003**	0.006***	0.004*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)**	(0.004)	(0.002)	(0.002)	(0.002)
Sigma	1.774		-		-		1.605		-	
	(0.092)						(0.181)			
N	512		512		512		230		230	

Notes: Dependent variable is the number of blocks purchased. Standard errors are given in parentheses. Significance levels 0.1, 0.05, and 0.01 are indicated by *, and **, and ***, respectively.

Table 4: Models of the participation decision in TCL&P's *Green Rate* program

	Model			
	Probit I		Probit II	
	Coefficient	Slope	Coefficient	Slope
Constant	-4.708***		-4.484***	
	(0.692)		(0.694)	
NEP	0.099***	0.024***	0.097***	0.023***
	(0.018)	(0.004)	(0.018)	(0.004)
ALT	0.099***	0.024***	0.099***	0.024***
	(0.021)	(0.005)	(0.021)	(0.005)
AGE	-0.008	-0.002	-0.007	-0.002
	(0.006)	(0.001)	(0.006)	(0.001)
GENDER	0.098	0.024	0.106	0.025
	(0.144)	(0.034)	(0.145)	(0.035)
HOUSEHOL	-0.051	-0.012	-0.014	-0.003
	(0.064)	(0.015)	(0.066)	(0.016)
INC000	0.025	0.001	0.004*	0.001*
	(0.002)	(0.001)	(0.002)	(0.001)
ELECDAY	-	-	-0.017**	-0.004**
			(0.008)	(0.002)
N	528		526	

Notes: Dependent variable is binary variable representing program participation (1=*yes*; 0=*no*). Standard errors are given in parentheses. Significance levels 0.1, 0.05, and 0.01are indicated by *, and **, and ***, respectively.

Appendix

This appendix lists the items used to create the *NEP* and *ALT* scales used in the empirical analysis. The scales differed somewhat and are listed separately for the Detroit Edison and TCL&P survey.

NEP scale items used in the Detroit Edison survey:
1. The balance of nature is very delicate and easily upset.
2. Plants and animals have as much right as humans to exist.
3. Humans will eventually learn enough about how nature works to be able to control it.
4. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
5. If things continue on their present course, we will soon experience a major ecological catastrophe.
6. Humans were meant to rule over the rest of nature.
7. The earth is like a spaceship with very limited room and resources.
8. Human ingenuity will insure that we do not make the earth unlivable.
9. We are approaching the limit of the number of people the earth can support.
10. The balance of nature is strong enough to cope with the impacts of modern industrial nations.

ALT scale items used in the Detroit Edison survey:
1. I worry about conserving energy only when it helps to lower my utility bills.
2. Contributions to community organizations can greatly improve the lives of others.
3. The individual alone is responsible for his or her satisfaction in life.
4. It is my duty to help other people when they are unable to help themselves.
5. Many of society's problems result from selfish behavior.
6. Households like mine should not be blamed for environmental problems caused by energy production and use.
7. My responsibility is to provide only for my family and myself.
8. Use of renewable energy is the best way to combat global warming.
9. My personal actions can greatly improve the well-being of people I don't know.

NEP scale items used in the TCL&P survey:
1. Plants and animals have as much right as humans to exist.
2. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
3. Human ingenuity will insure that we do not make the earth unlivable.
4. The earth is like a spaceship with very limited room and resources.
5. The balance of nature is strong enough to cope with the impacts of modern industrial nations.

ALT scale items used in the TCL&P survey:
1. Contributions to community organizations rarely improve the lives of others.
2. The individual alone is responsible for his or her well-being in life.
3. It is my duty to help other people when they are unable to help themselves.
4. Many of society's problems result from selfish behavior.
5. My responsibility is to provide only for my family and myself.
6. My personal actions can greatly improve the well-being of people I don't know.